

## **Abstract of Invention**

A bi-functional oxidation catalyst and process for catalytic oxidation and removal of nitrogen oxides ( $\text{NO}_x$ ) from combustion gases derived from combustion of carbonaceous fuels such as coal, oil, or natural gas. The bi-functional catalyst includes adsorption and oxidation function metal oxides provided in adjacent close intimate contact by utilizing a binding agent, such as carboxylic acid and calcining to provide a metal oxide complex having a crystalline form. Such nitrogen oxides ( $\text{NO}_x$ ) contained in the combustion gases are initially catalytically oxidized to at least about 50 vol %  $\text{NO}_2$  and some higher oxides by contact with the bi-functional catalyst at 170-550°F temperature. The combustion gas containing the partially oxidized  $\text{NO}_x$  is then preferably further chemically oxidized by being mixed with a chemical oxidant such as ozone ( $\text{O}_3$ ) in a molar ratio of the chemical oxidant, to  $\text{NO}_x$  in the range of 0.5:1-1.2:1 to produce higher oxides of nitrogen such as substantially  $\text{N}_2\text{O}_5$ .

The further treated combustion gas containing the  $\text{N}_2\text{O}_5$  is next scrubbed with a suitable scrubbing liquid such as water to effectively remove the nitrogen oxides ( $\text{NO}_x$ ) and produce a clean treated flue gas stream containing less than about 15 ppm nitrogen oxides and suitable for environmentally safe discharge to the atmosphere.